

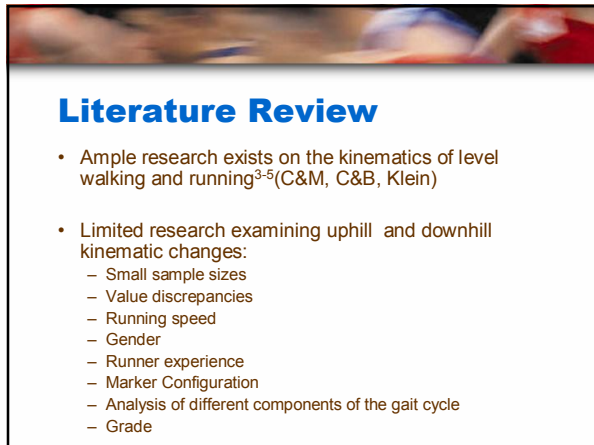
The Alterations of Lower Extremity Kinematics During Uphill and Downhill Running

Sponsoring Faculty: Dr. David Levine and Professor Jeremiah Tate
 Students: Shannon Wommack, Meghan Alexander, and James Robbins



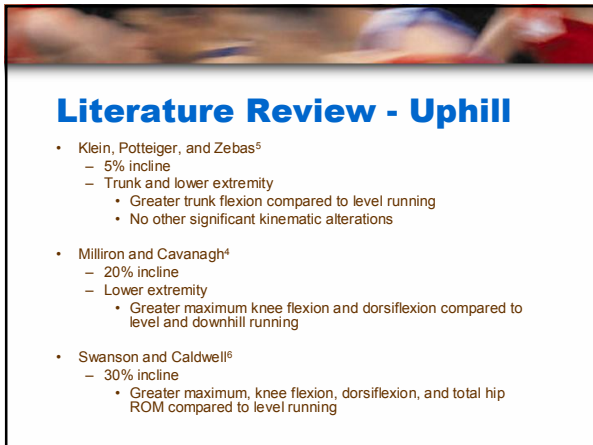
Popularity of Running

- Continues to be a sport engaged in by thousands of Americans
- 65% of runners are injured in an average year
- 1 injury/100 hours of running
- Runners miss 5-10% of their workouts due to injury¹
- Most Common Running Injuries:²
 - Plantar fasciitis
 - IT band friction syndrome
 - Shin splints
 - Patellar femoral pain
 - Achilles tendonitis



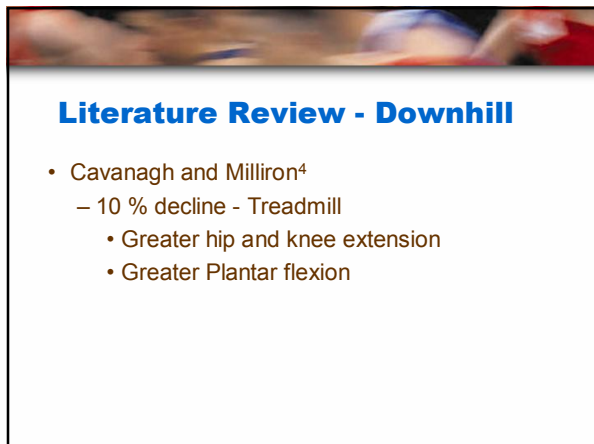
Literature Review

- Ample research exists on the kinematics of level walking and running³⁻⁵(C&M, C&B, Klein)
- Limited research examining uphill and downhill kinematic changes:
 - Small sample sizes
 - Value discrepancies
 - Running speed
 - Gender
 - Runner experience
 - Marker Configuration
 - Analysis of different components of the gait cycle
 - Grade



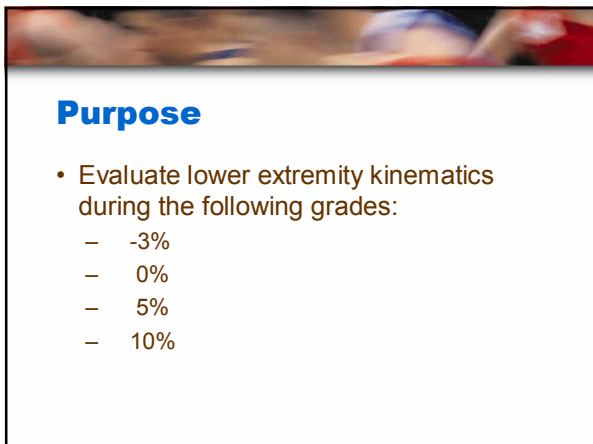
Literature Review - Uphill

- Klein, Potteiger, and Zebas⁵
 - 5% incline
 - Trunk and lower extremity
 - Greater trunk flexion compared to level running
 - No other significant kinematic alterations
- Milliron and Cavanagh⁴
 - 20% incline
 - Lower extremity
 - Greater maximum knee flexion and dorsiflexion compared to level and downhill running
- Swanson and Caldwell⁶
 - 30% incline
 - Greater maximum, knee flexion, dorsiflexion, and total hip ROM compared to level running



Literature Review - Downhill

- Cavanagh and Milliron⁴
 - 10 % decline - Treadmill
 - Greater hip and knee extension
 - Greater Plantar flexion



Purpose

- Evaluate lower extremity kinematics during the following grades:
 - -3%
 - 0%
 - 5%
 - 10%

Hypotheses

1. Hip flexion will increase with an uphill grade
2. Hip flexion will decrease with a downhill grade
3. Knee flexion will increase with an uphill grade
4. Knee flexion will decrease with a downhill grade
5. Ankle dorsiflexion will increase with an uphill grade
6. Ankle plantar flexion will increase with a downhill grade.

Methods: Subjects

16 Collegiate runners (8 male, 8 female) from the UTC population

- Demographics
 - Mean age – 20.9 years
 - Times running per week – 6.9
 - Miles per week – 59.8
 - Ht. – 172.9 cm (68.1 in.)
 - Wt. – 62.1 kg (136.9 lbs.)
- Exclusion
 - Less than 18 y. o.
 - Older than 30 y. o.
 - Toe or midfoot striker on level ground
 - Current bone, muscle or joint injury
 - No treadmill experience

Methods: Experimental Protocol

- 9 reflective markers
 - S2
 - Bilateral:
 - ASIS
 - lateral femoral epicondyles
 - lateral malleoli
 - 2nd metatarsal



Methods: Experimental Protocol

- Randomized order of 4 trials (-3%, level, 5%, and 10% grade)
- Warm-up 4 minutes
- Perform four trials 60 seconds
 - 3.0m/s (6.5 mph=8 minute mile)
 - 5 seconds of data was collected at end of each trial without the runners knowledge
- No rest between each trial

Methods: Instrumentation

- Static and dynamic calibration with six camera Vicon 370 motion analysis system

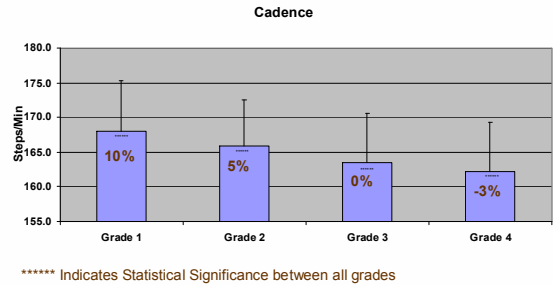
Data Reduction

- 3-D data was exported from the Vicon System to Microsoft Excel spreadsheet
- Data was processed using a macro program written in Visual Basic to determine:
 - Cadence
 - Sagittal plane angles of the hip, knee, and ankle

Methods: Statistical Analysis

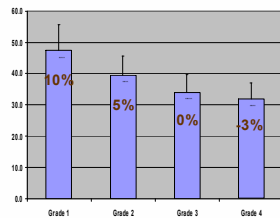
- Data was transferred into Windows SPSS 13.0 for statistical analysis to determine the means and SD of joint angles
- One-way ANOVA for repeated measures

Results: Cadence



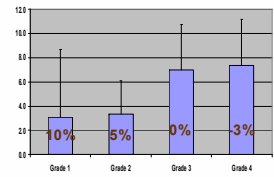
Results: Maximum Hip Flexion

Grade	Change	p value
10%	13.6°	< 0.001
5%	5.5°	< 0.001
-3%	-2.2°	< 0.001



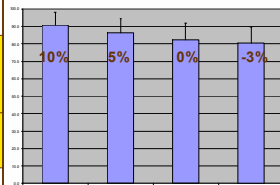
Results: Maximum Hip Extension

Grade	Change	p value
10%	-4.0°	< 0.001
5%	-3.6°	< 0.001
-3%	0.4°	= 0.367



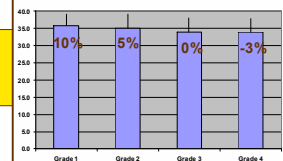
Results: Maximum Knee Flexion

Grade	Change	p value
10%	8.5°	< 0.001
5%	4.1°	= 0.001
-3%	-1.4°	= 0.105



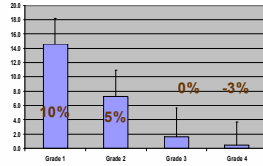
Results: Stance Phase Knee Flexion

Grade	Change	p value
10%	1.8°	= 0.003
5%	1.1°	> 0.05
-3%	0.1°	> 0.05



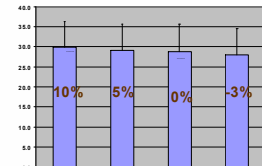
Results: Maximum Knee Extension

Grade	Change	p value
10%	13.0°	> 0.05
5%	5.7°	> 0.05
-3%	-1.1°	> 0.05



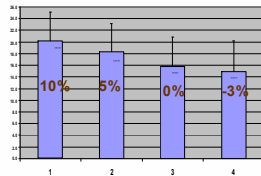
Results: Maximum Ankle Plantarflexion

Grade	Change	p value
10%	1.2°	= 0.006
5%	0.4°	= 0.425
-3%	-1.9°	= 0.160



Results: Maximum Ankle Dorsiflexion

Grade	Change	p value
10%	4.3°	< 0.001
5%	2.5°	< 0.001
-3%	-0.9°	= 0.004



Discussion

- We accept the following hypotheses:
 1. Hip flexion will increase with an uphill grade
 3. Knee flexion will increase with an uphill grade
 5. Ankle dorsiflexion will increase with an uphill grade
- We reject the following hypotheses:
 2. Hip flexion will decrease with a downhill grade
 4. Knee flexion will decrease with a downhill grade
 6. Ankle plantar flexion will increase with a downhill grade
- Trend was noted with all rejected hypotheses

Discussion

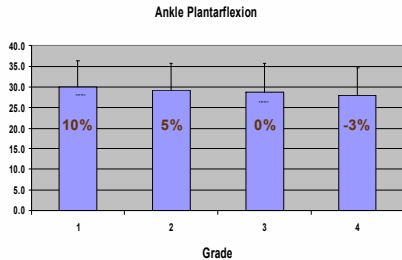
- Peak Hip Extension
 - Trend for increased extension with downhill grade
 - Cadence
 - Forward trunk flexion with uphill running
 - Trunk extension with downhill running
 - Lower values
 - Marker configuration
 - Velocity
 - Equipment limitations
 - Orientation of pelvis during downhill running (Levine/Whittle)

Discussion

- Peak Knee Extension
 - Statistically significant for all grades except level and downhill
 - Power
 - Small change
 - Small extension values
 - Marker configuration
 - Component of gait cycle value was recorded
 - Speed
 - Increased speed → increased flexion⁶

Discussion

- Ankle Maximum
 - Limited number of subjects
 - Large variation between participants
 - No experience running downhill on TM



Study Comparison

- Klien et al⁵ – 5% incline
 - No significant difference in lower extremity kinematics
 - Marker configuration, stance phase analysis only
- Cavangh and Milliron⁴ -10%, level, and 10% downhill
 - Found similar trends for lower extremity kinematics
- Swanson and Caldwell⁶ - 30% incline
 - Greater maximum hip flexion, knee flexion, dorsiflexion and total hip range of motion when compared to level running.

Clinical Significance

- Effective assessment and diagnosis
- Injury prevention 2° to abnormal running gait
- Understanding the effects of grade
- HEP recommendations

Discussion: Could injury be related to grade?

- Achilles Tendonitis
 - Loading during uphill running
 - Requiring near full range
- Hamstring strain
 - Greater force required for propulsion during uphill running
 - Greater tension across joint due to increased hip flexion
- IT band Friction Syndrome⁸
 - Reported to be mostly associated with downhill running
 - Eccentric loading
 - Knee travels through less range

Discussion

- IT band Friction Syndrome, Plantar Fasciitis, and Shin Splints⁸
 - Reported to have limited dorsiflexion
 - Running uphill may exacerbate symptoms due to lack of dorsiflexion
- Knee Extension and Injury
 - F_N greater in downhill running
 - 13% larger vertical impact force in downhill running
 - Combined with knee extension and reduced shock absorption ability
 - Injured runners may benefit from uphill running versus downhill running⁹

Limitations

- Subject number
 - Competitive runners only
- Treadmill
 - Limited downhill grade



Conclusion

- 10%, 5% and -3% grade cause significant changes in cadence and lower extremity kinematics when compared to level running in collegiate runners.
 - Cadence, hip flexion, and dorsiflexion have direct and significant correlations to grade.
 - Grade has little effect on plantarflexion and stance phase knee flexion.



Future Research

- Increase generalizability
- Increase decline grade
- Taping method
- Marker configuration
- Compare gender



References

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